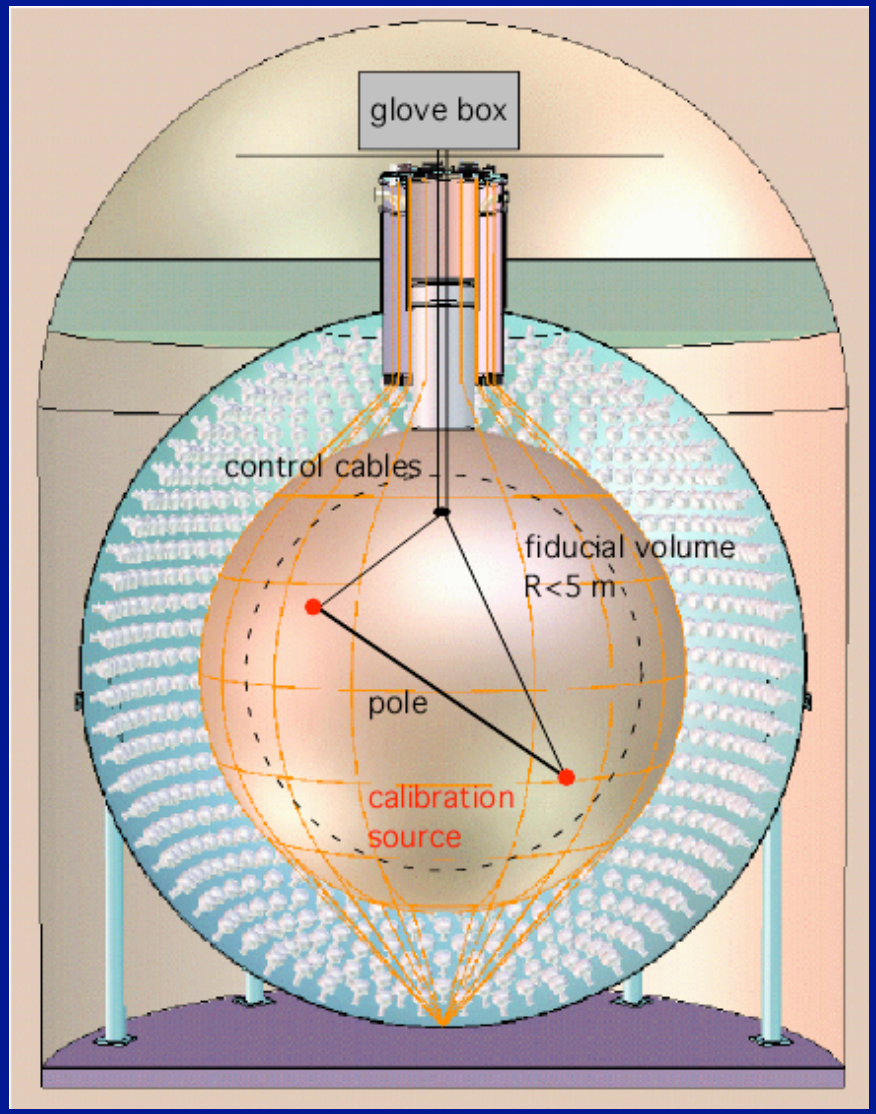
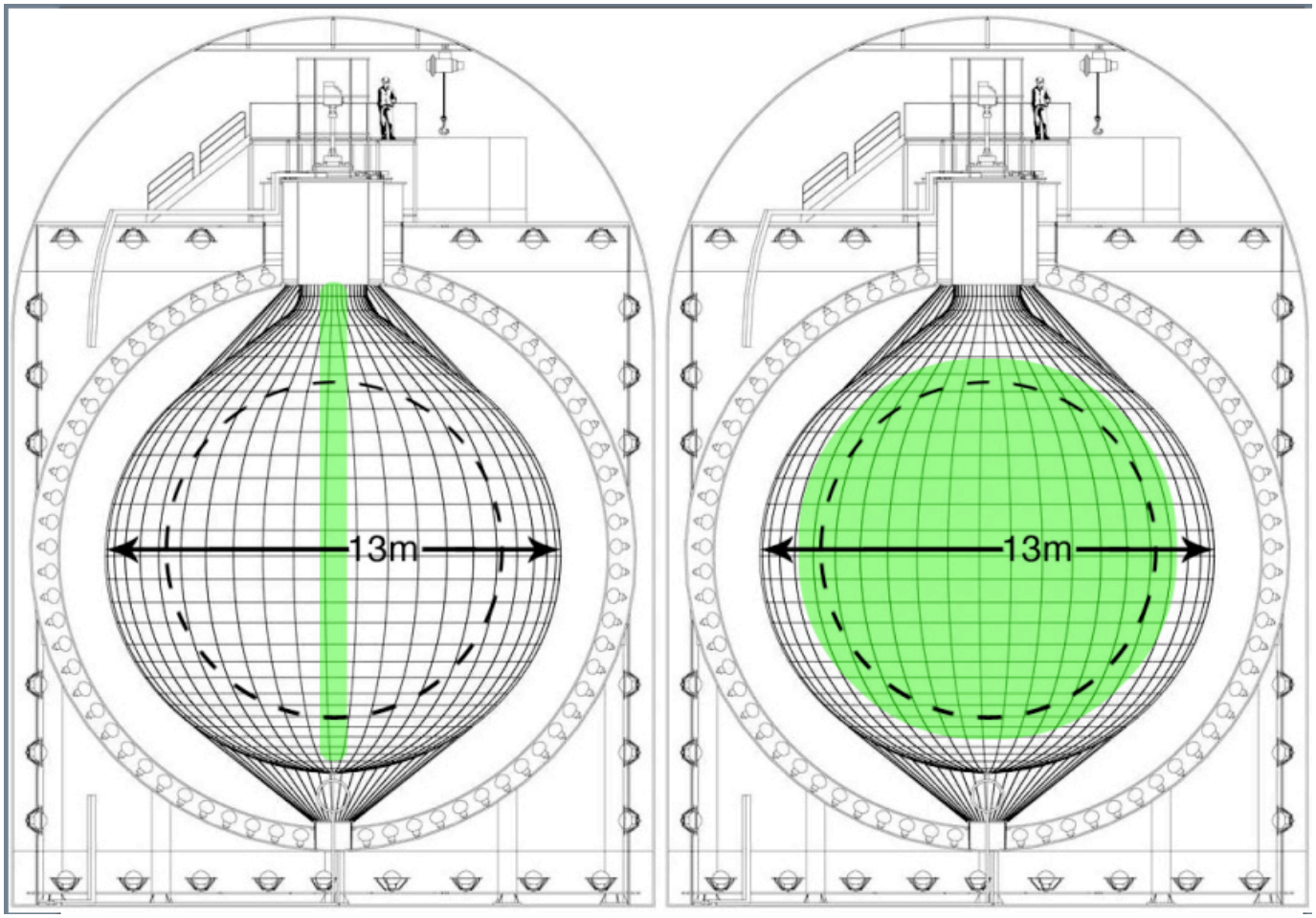
Development and Testing of an Off-Axis Calibration System for KamLAND



It's being built!

KamLAND 4 Group
Lawrence Berkeley National Laboratory

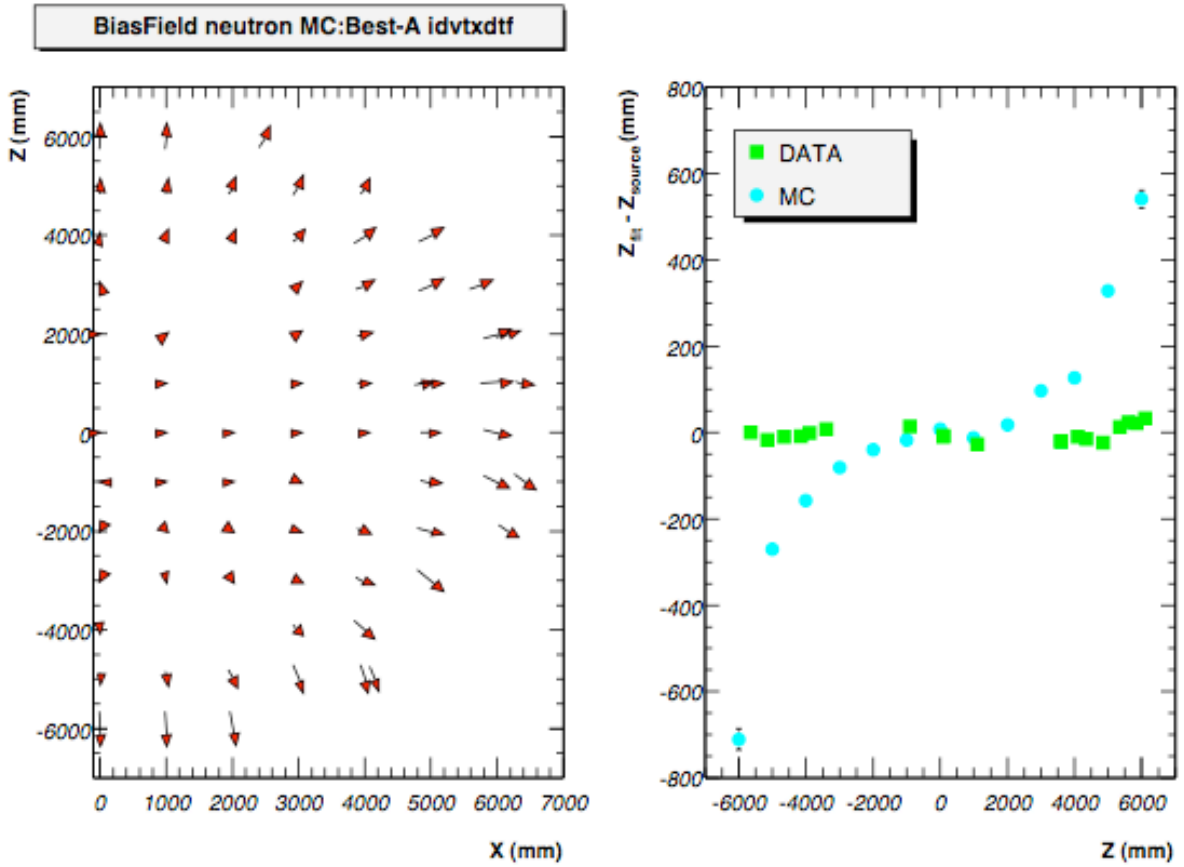
Fiducial Volume Requirements



Understanding the fiducial volume → absolute flux

energy response → spectrum

Understanding the Reconstruction Bias



From AKat 2002 analysis

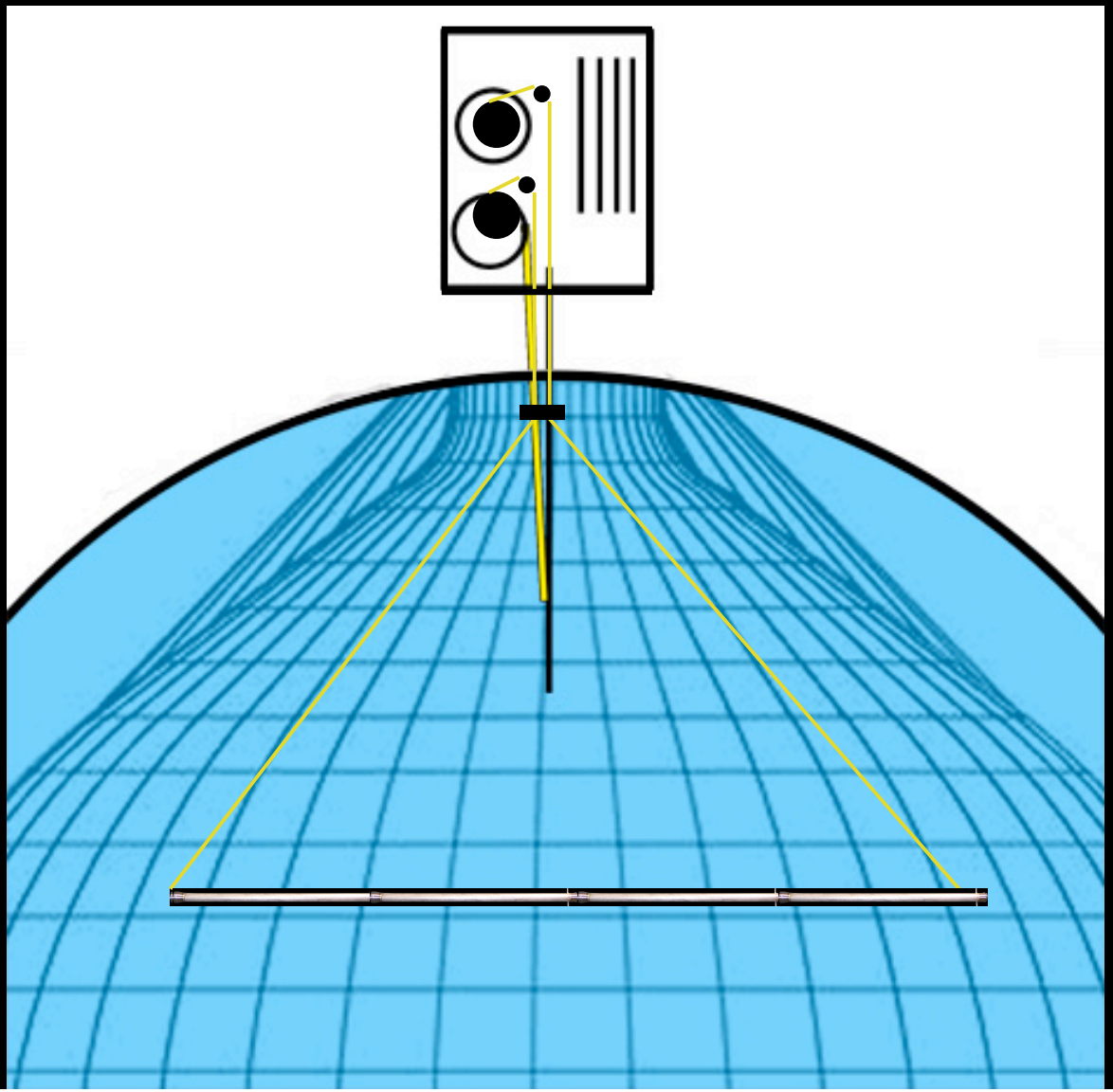
- Bias correction to number of candidate events is up to 10%.

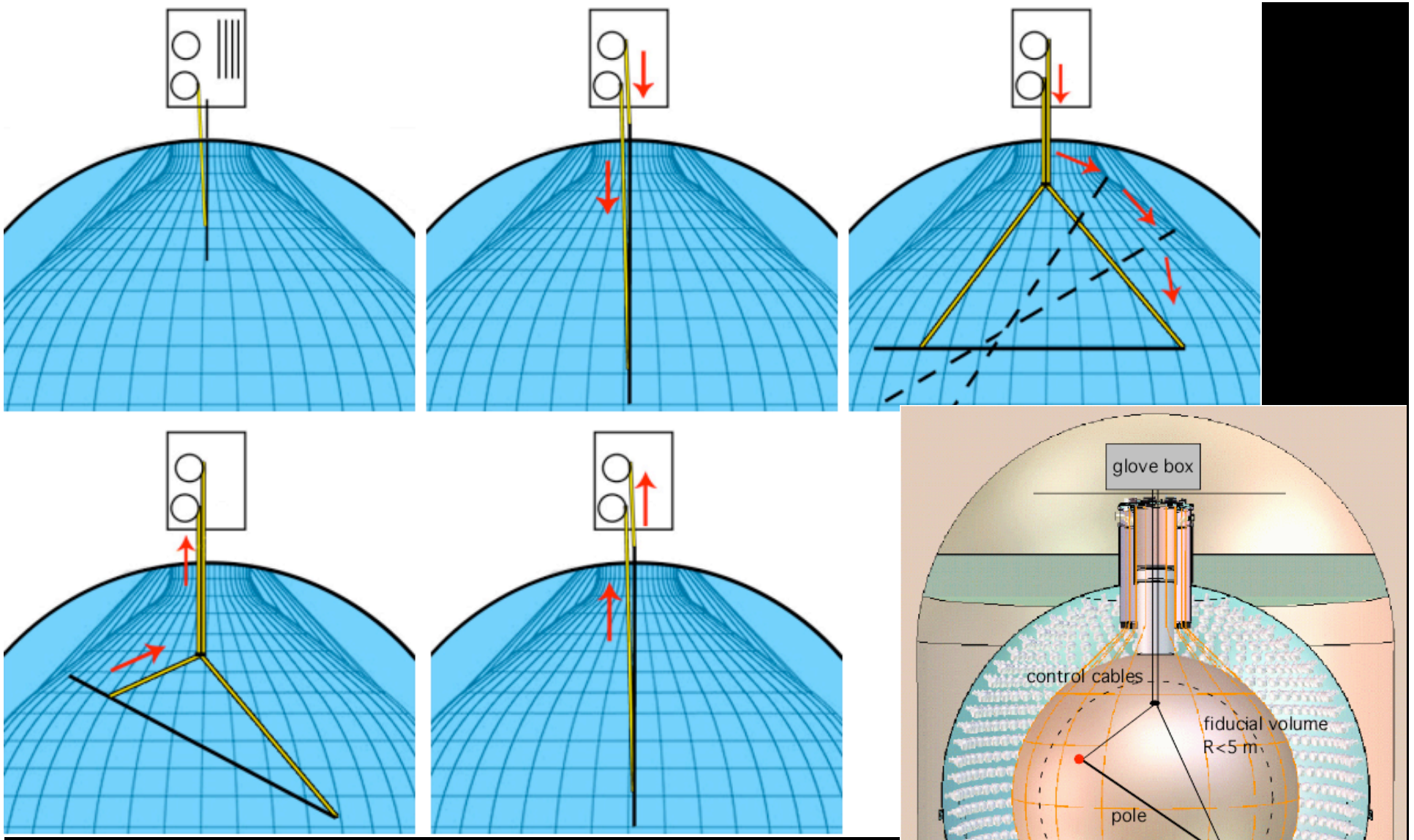
Design Criteria and Functionality

- provide off-axis calibrations with minimal interference with the detector and its systems
- safely deploy and retrieve passive calibration sources
- allow for an accurate position determination of the source
- adjust the radial and angular position of the calibration source
- provide redundant monitoring and safety measures

The KamLAND Off-Axis Calibration System

- Segmented calibration pole
- Two control cables
- Motorized winches
- Modified glove box



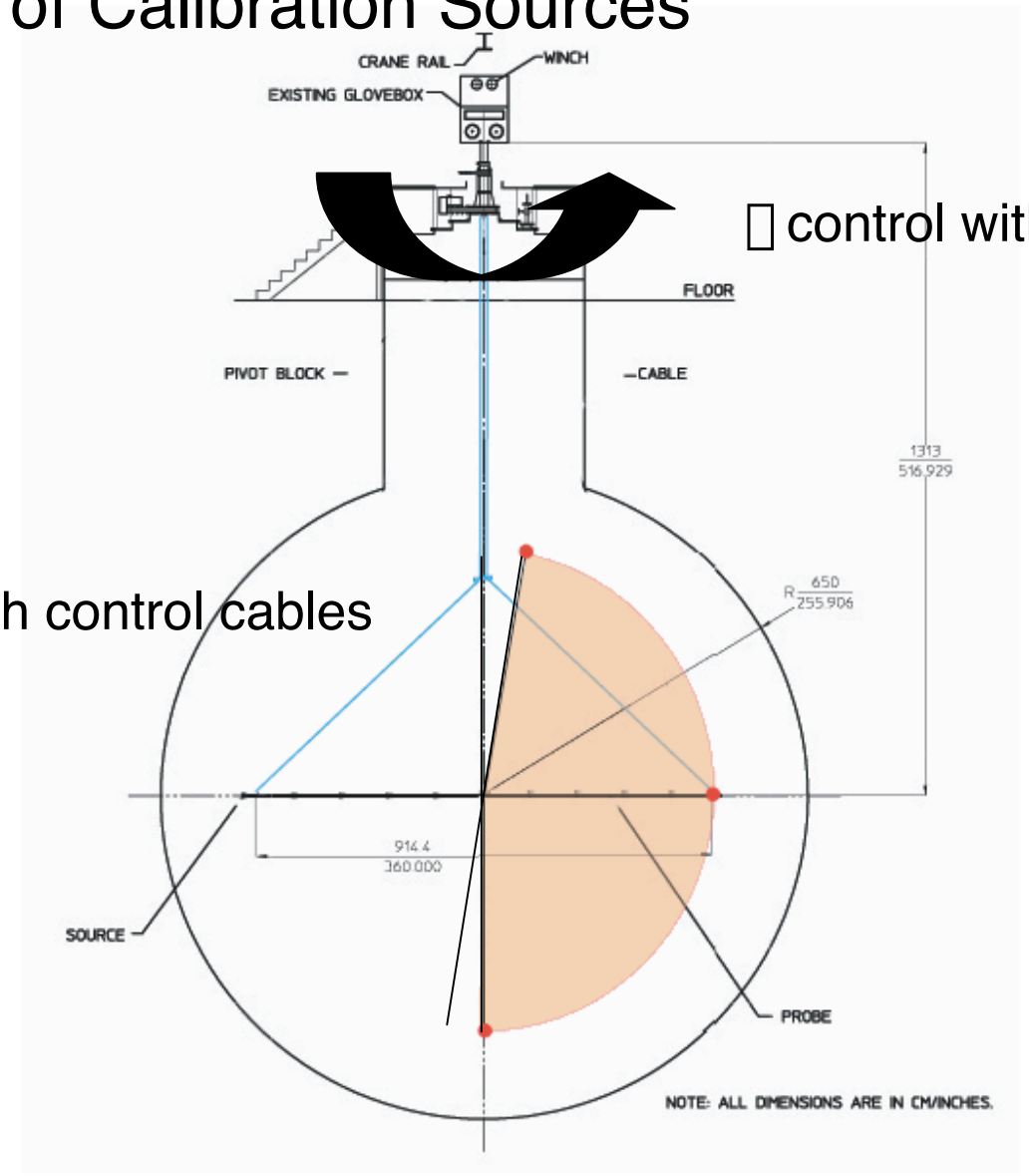


Deployment Sequence

Positioning of Calibration Sources

 control with rotary stage

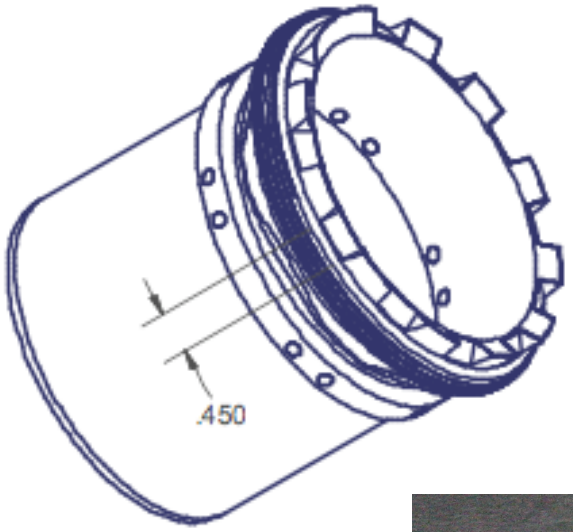
, z control with control cables



Calibration Pole

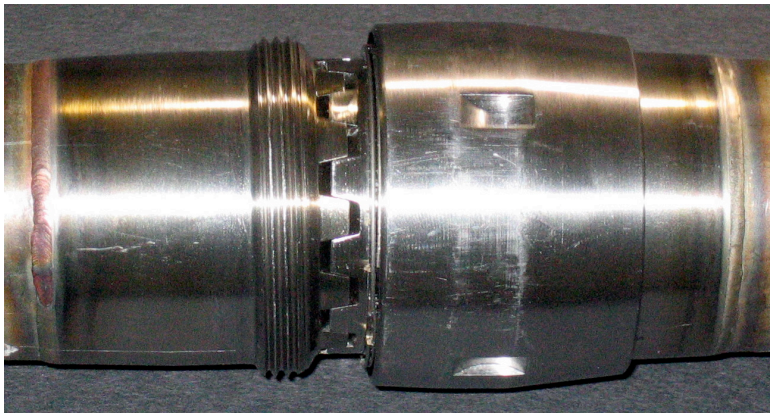
- 7 to 9 segments
- Each segment is 3’ long
- 1.5” titanium tubing (reduces weight and increase safety)
- Bicycle Torque Couplings (BTC) used to connect segments together
- .25” pins for deployment safety and for proper tightening of the couplings

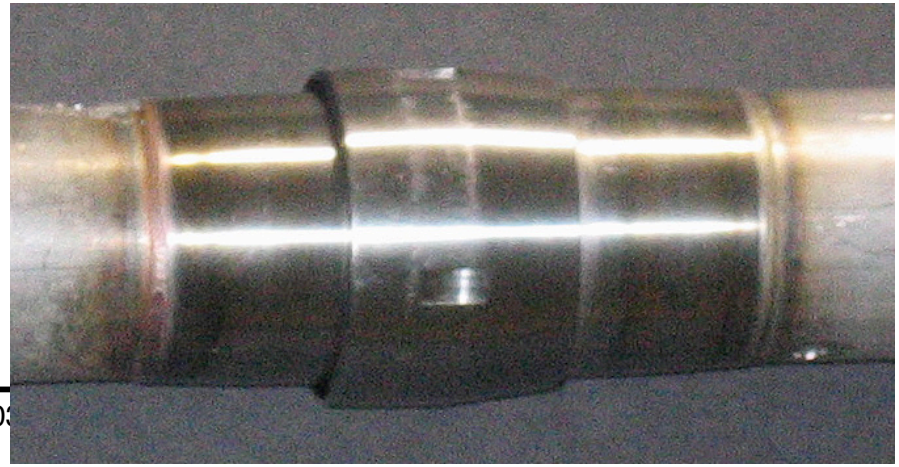
Pole Segment



Bicycle Torque Coupling (BTC)

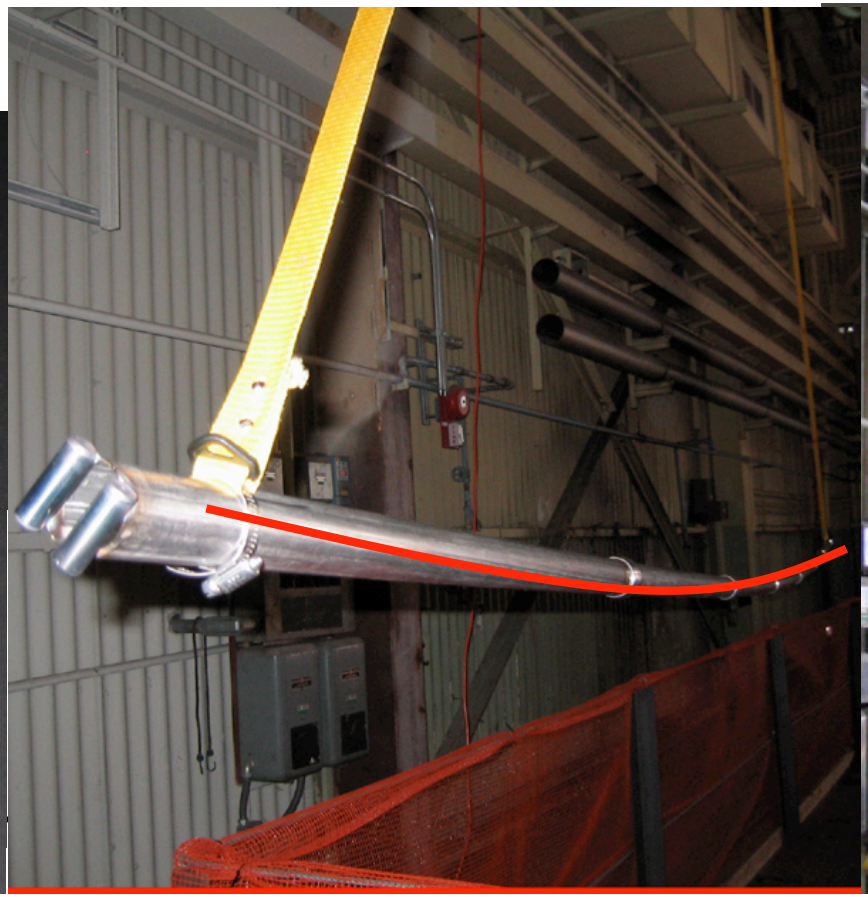
- Designed to combine tube segments on bicycles





Controlled Assembly of Couplings

- Minimizes deflection in pole
- 35 ft/lbs recommended
- Tightened to 25 ft/lbs (with our wrench) the deflection is ~4.25”
- Hand tightened the deflection is ~18”



Internal Safety Line

Purpose

- Safety line in the event of a BTC failure
- Hoist attachment during retrieval

- Eye bolt on the lower segment

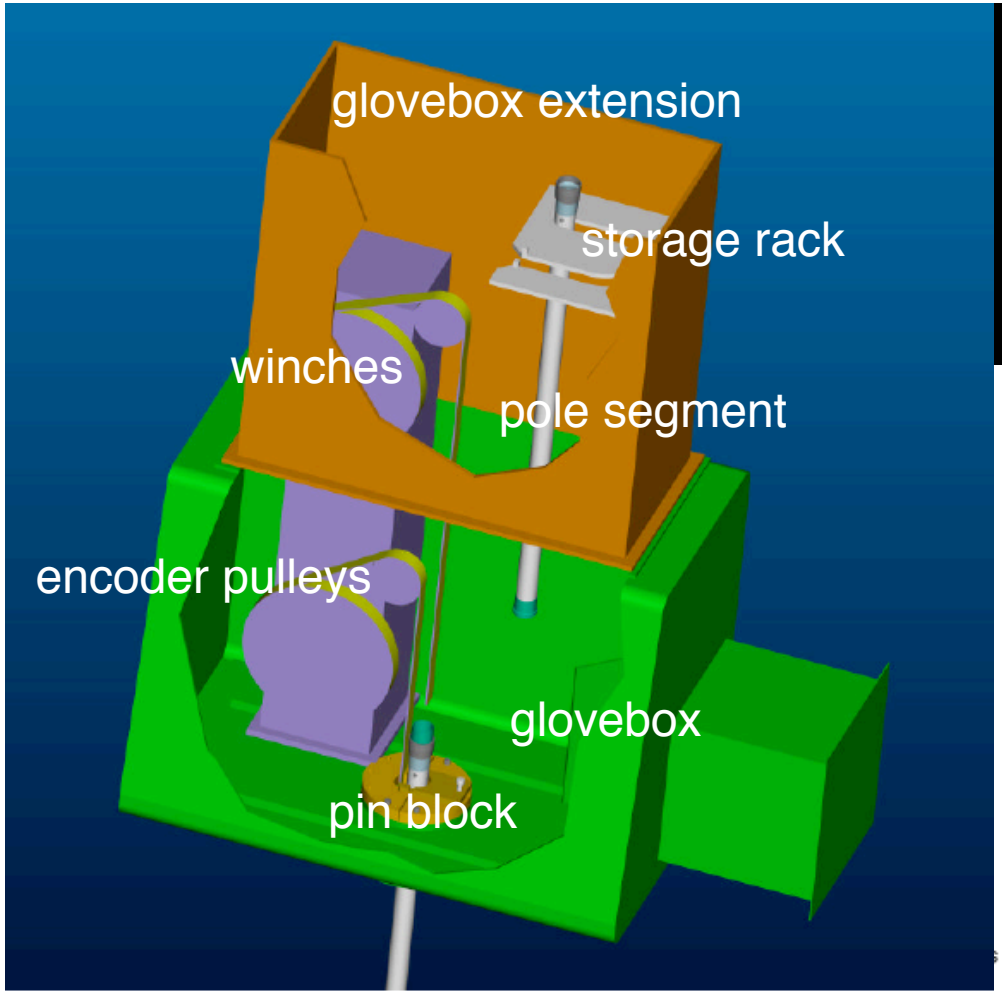
- Carabineer on a lanyard on the high side

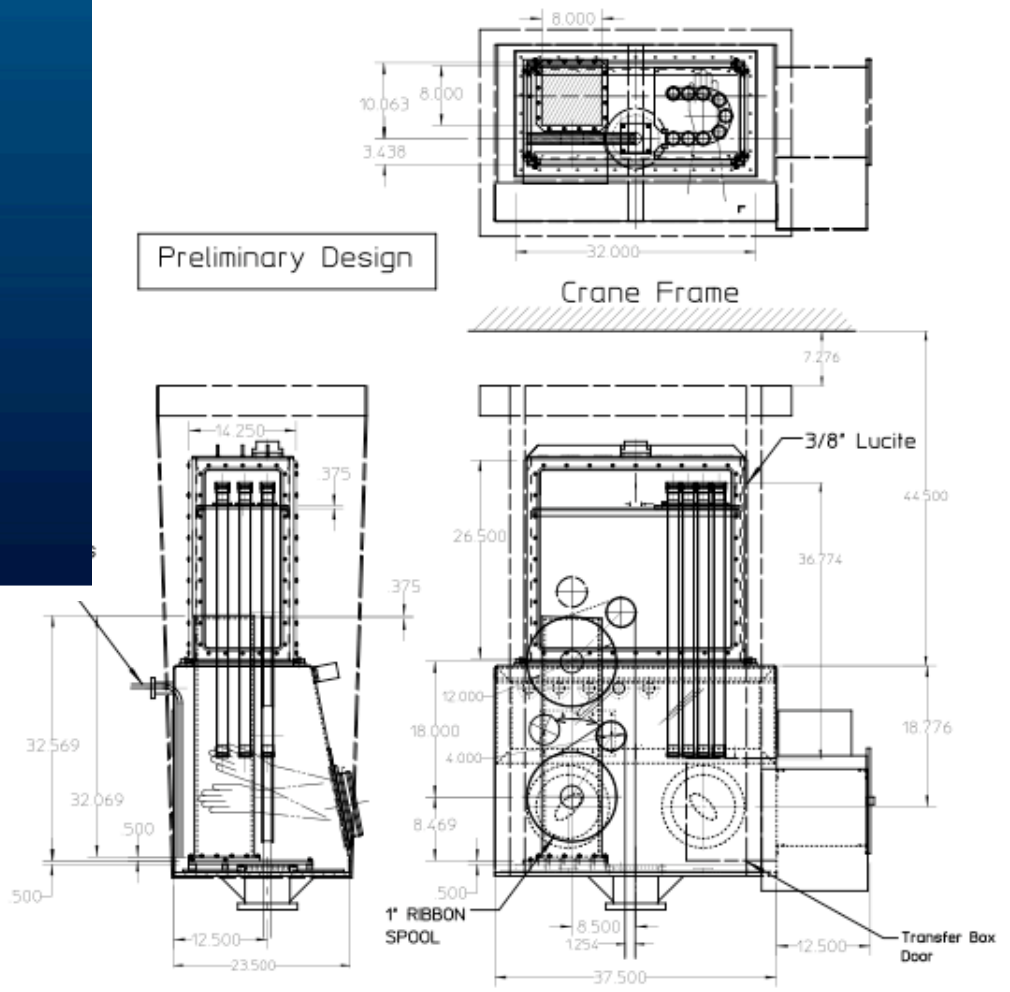
- During assembly in glovebox connect carabineer to lower segment

Calibration Source

Source holder identical in design to the current z-axis system.

Glove Box and Deployment Mechanism





Pin Block

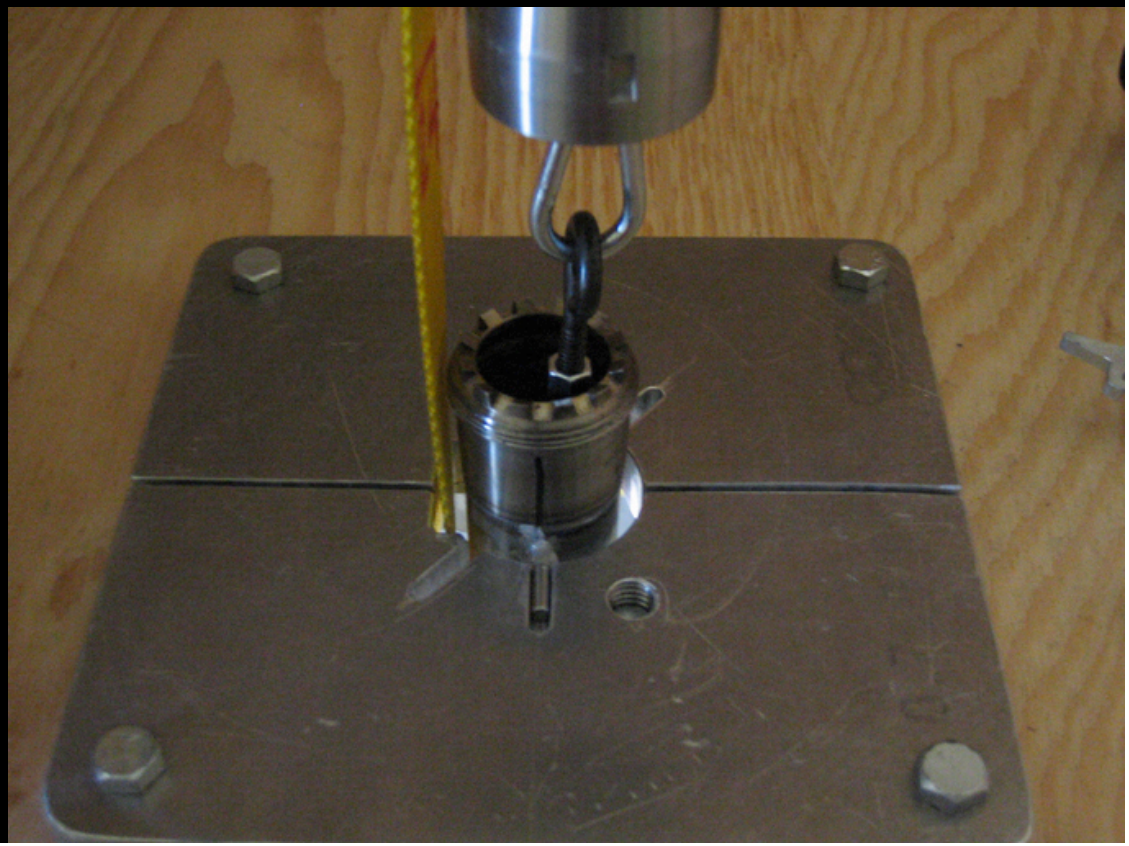
Purpose

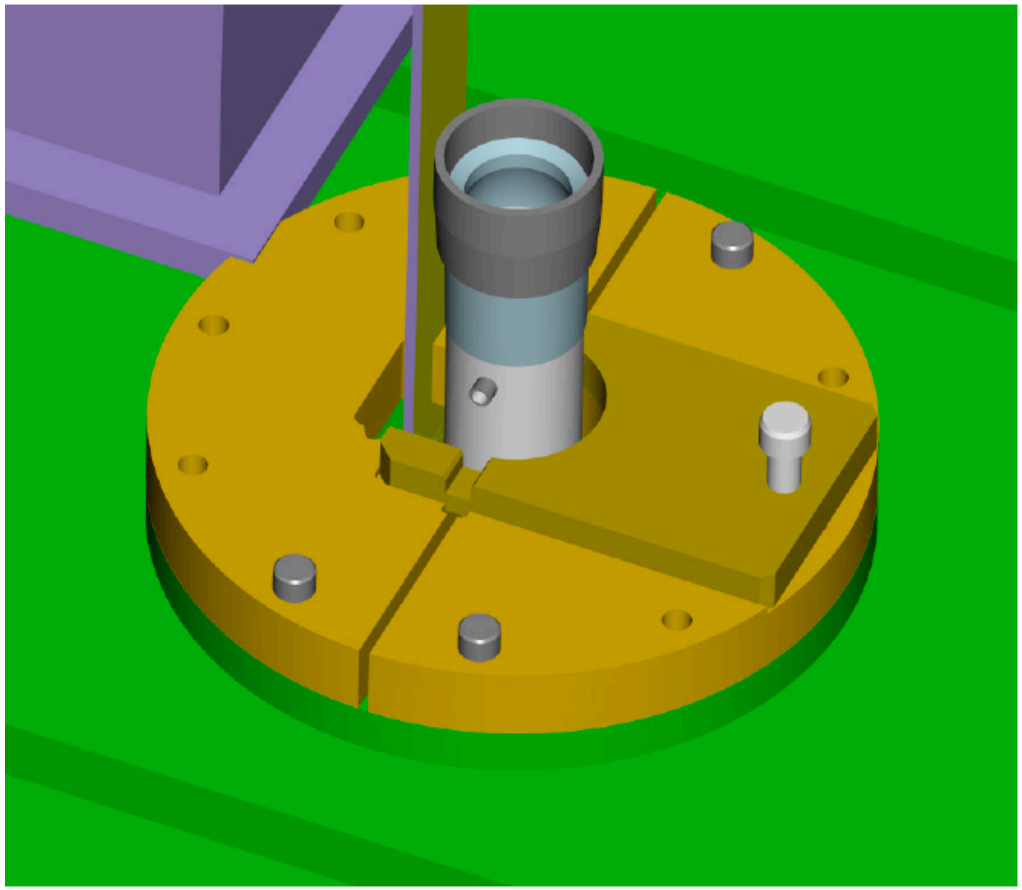
- covers the 6” hole
- failsafe interface between interior of glovebox and inner detector
- used for the assembly of the calibration pole

-slot for tightening the BTC coupling

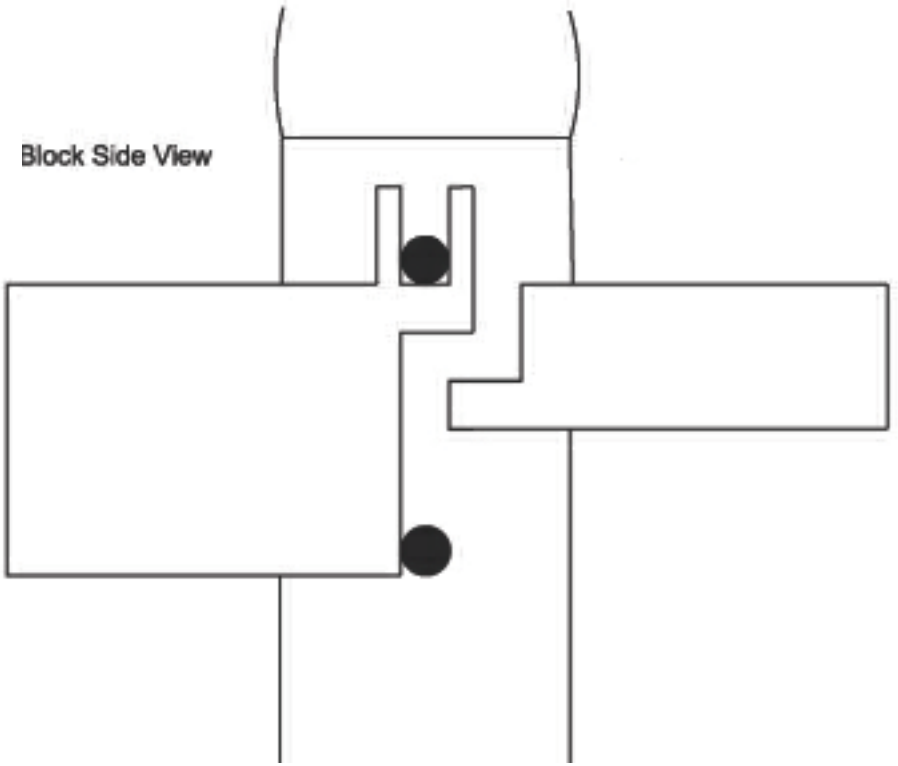
- requires turn to lower pole into inner detector

- sliding pin block allows for easy and reliable recovery

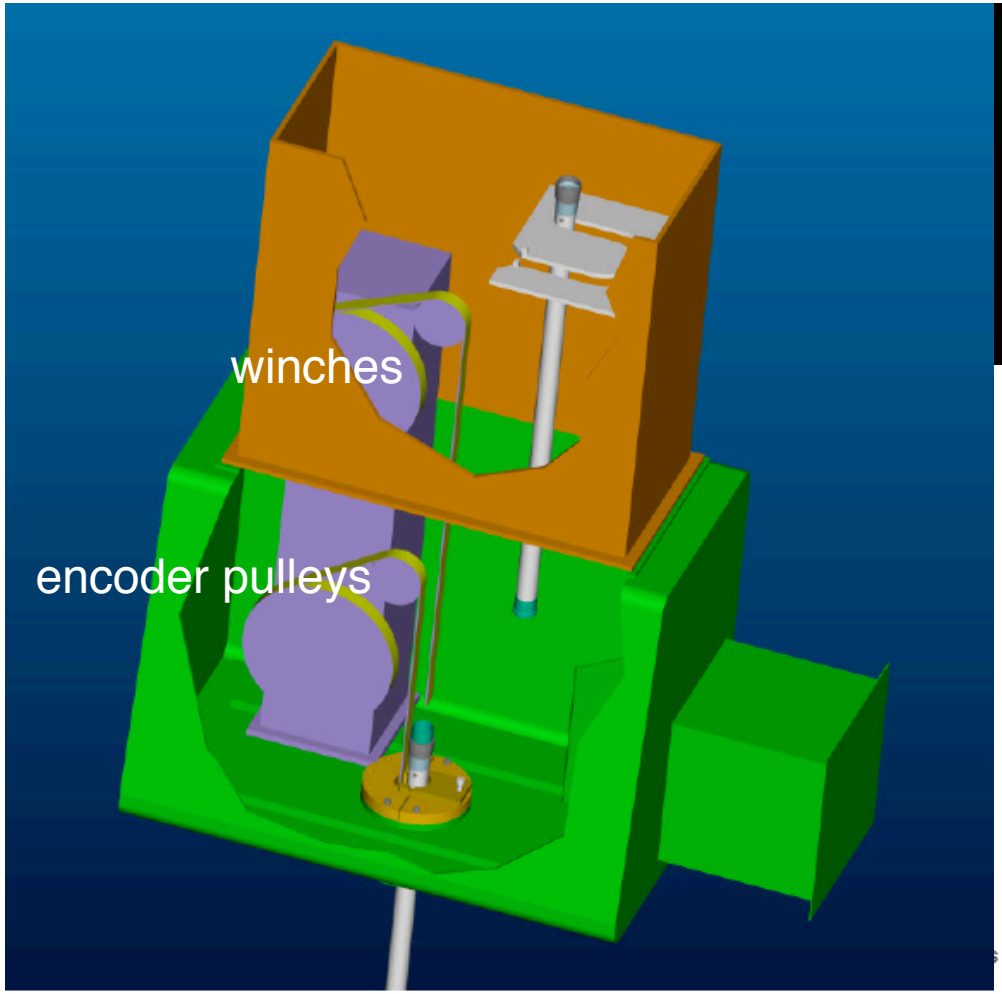


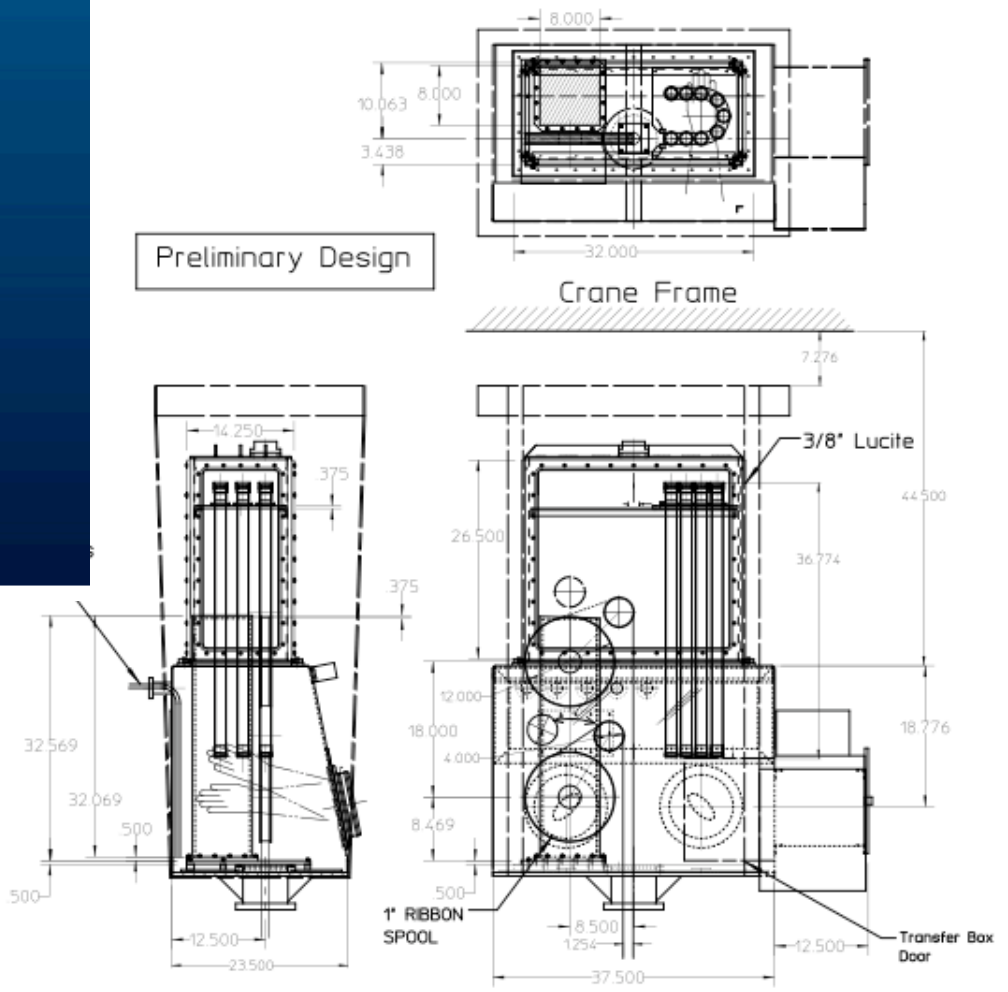


Pin Block

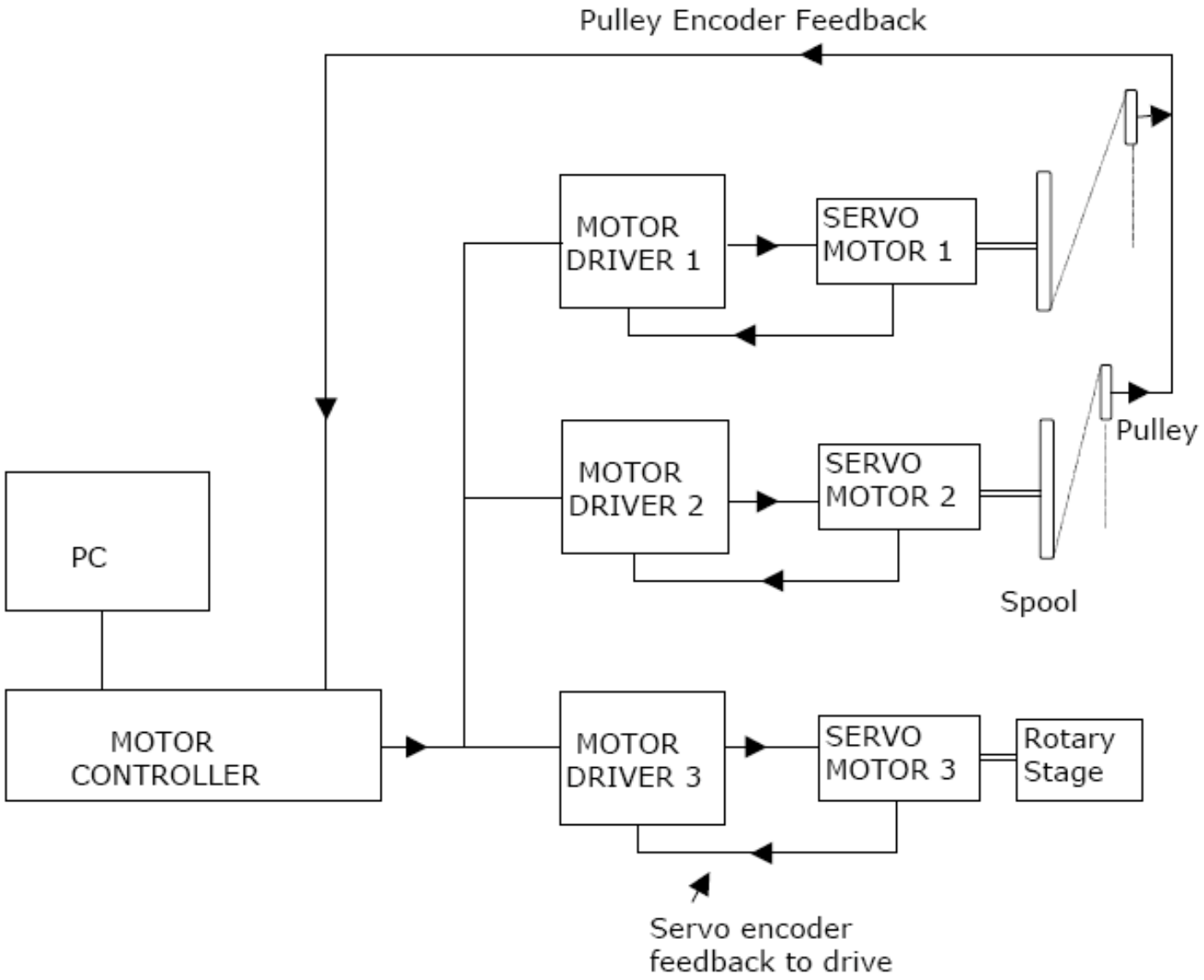


Glove Box and Deployment Mechanism

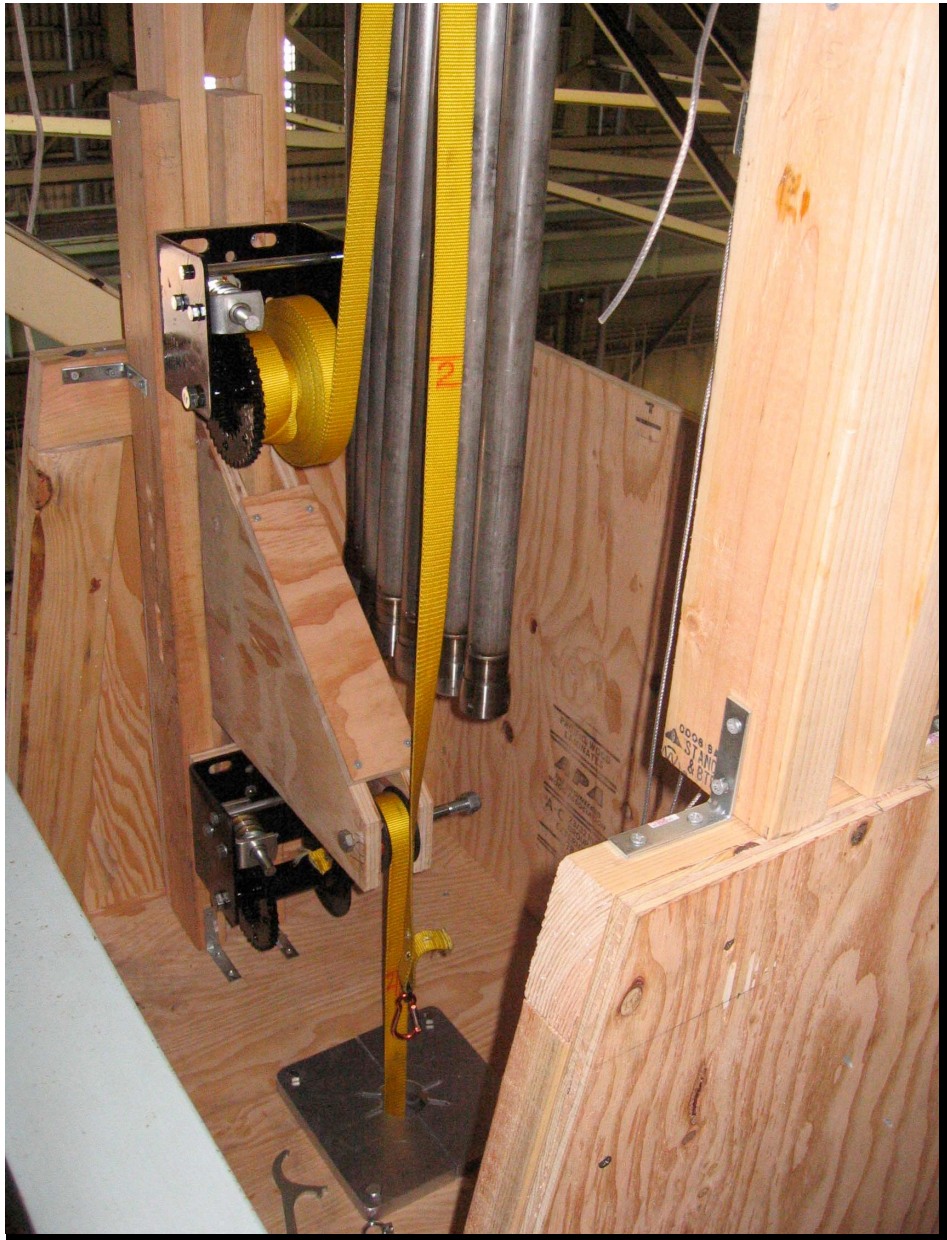


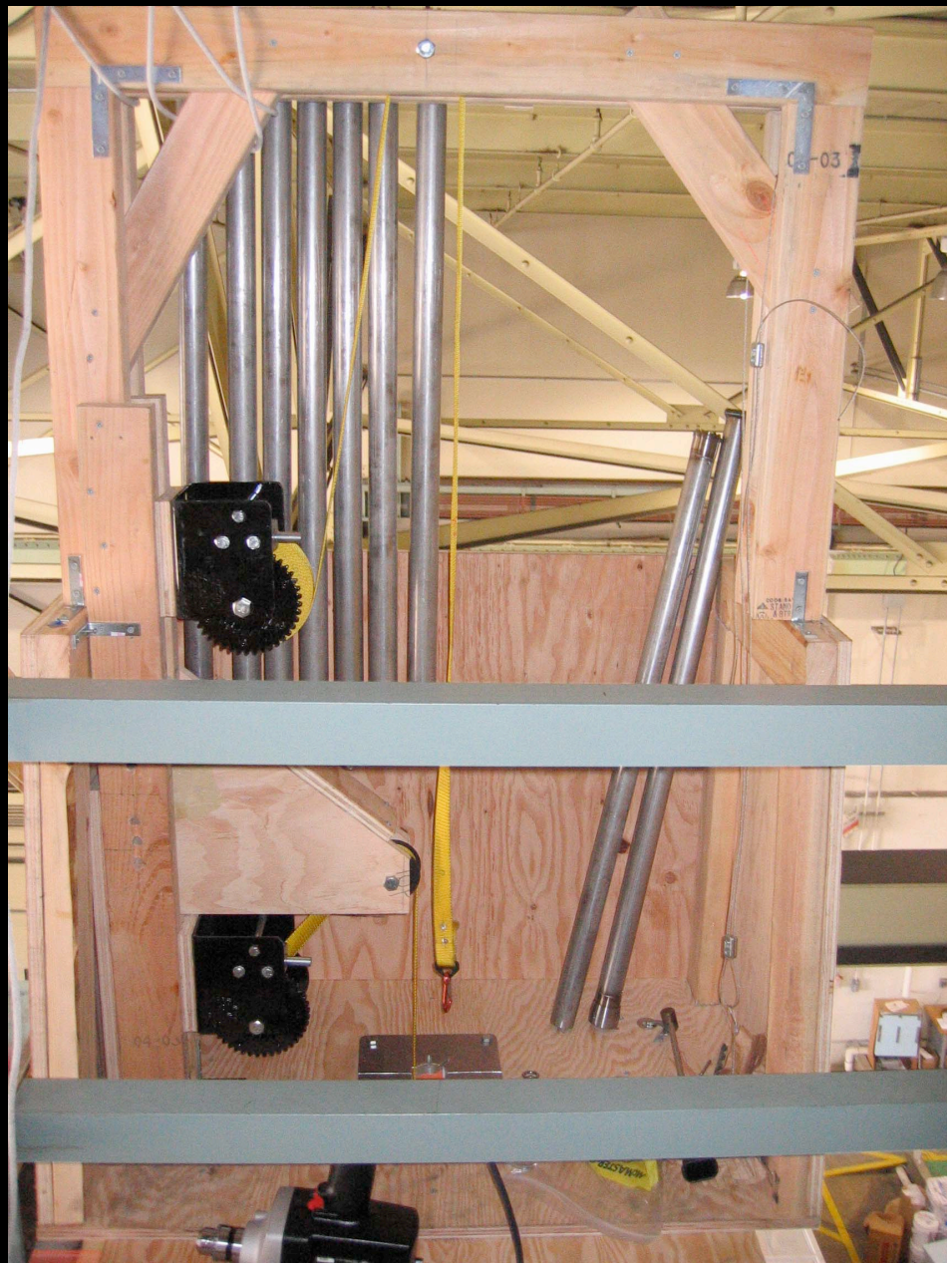


Motor Controls

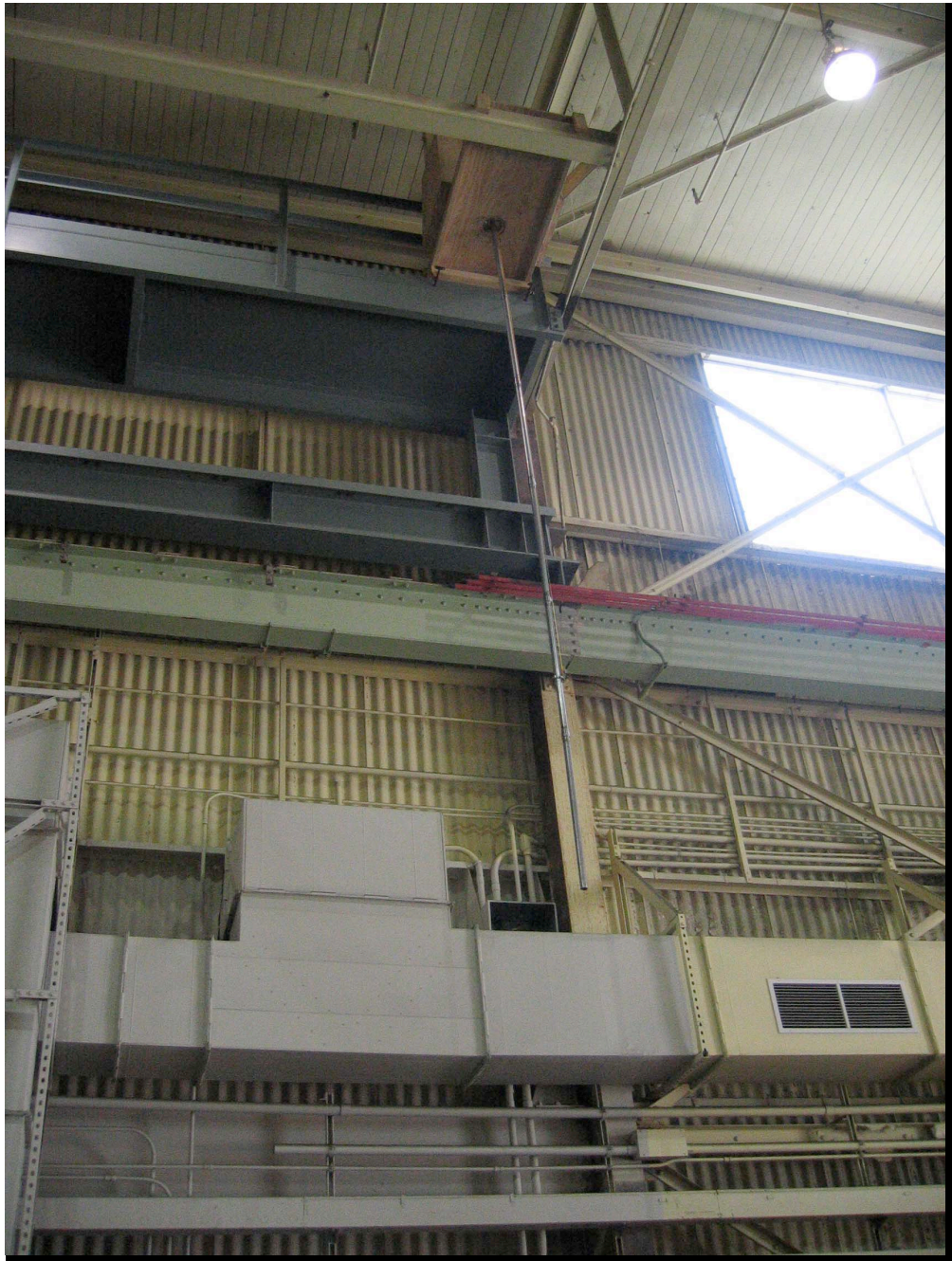


Prototype Testing

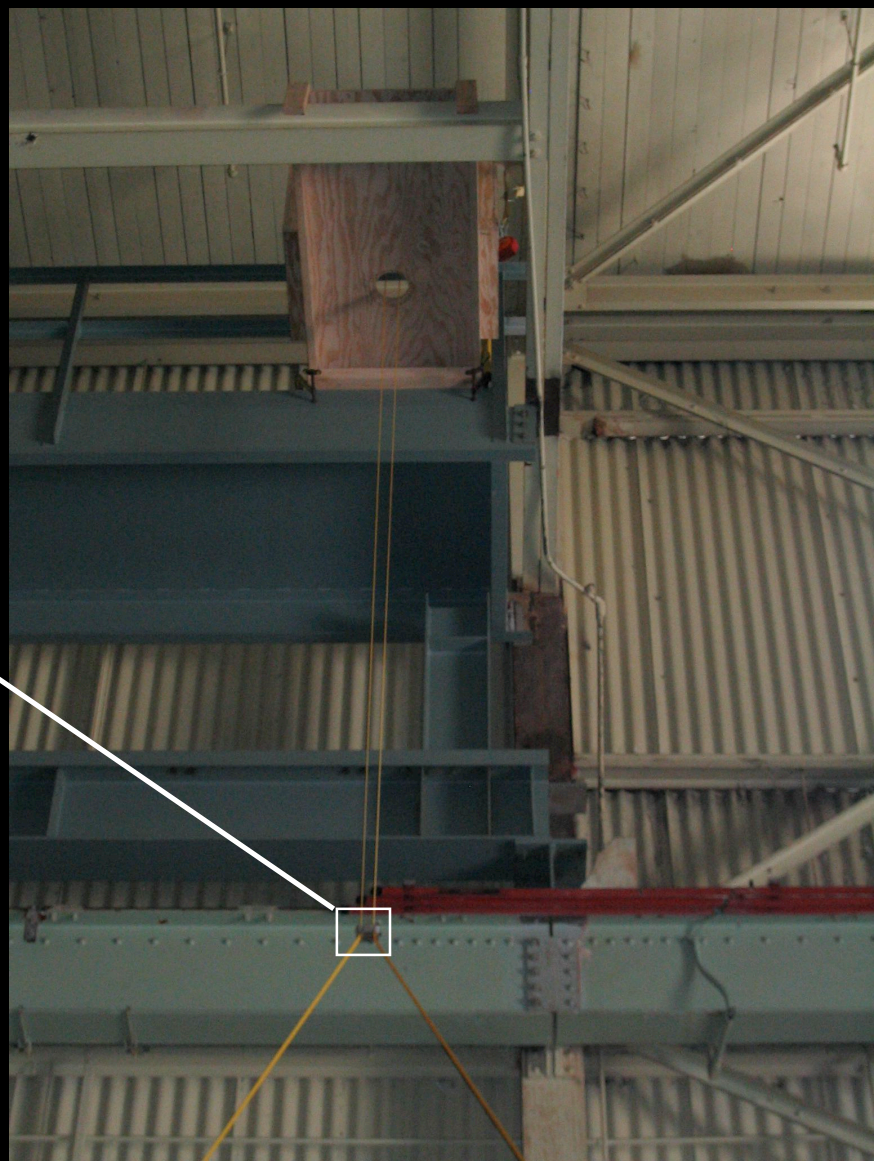




Prototype and Test Setup



Pivot Block



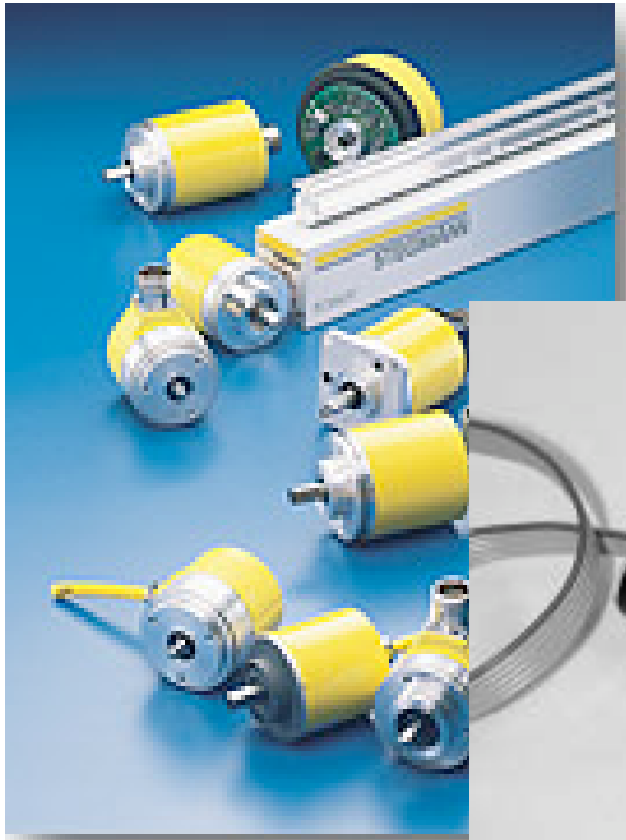
Prototype Operation

Position Adjustment

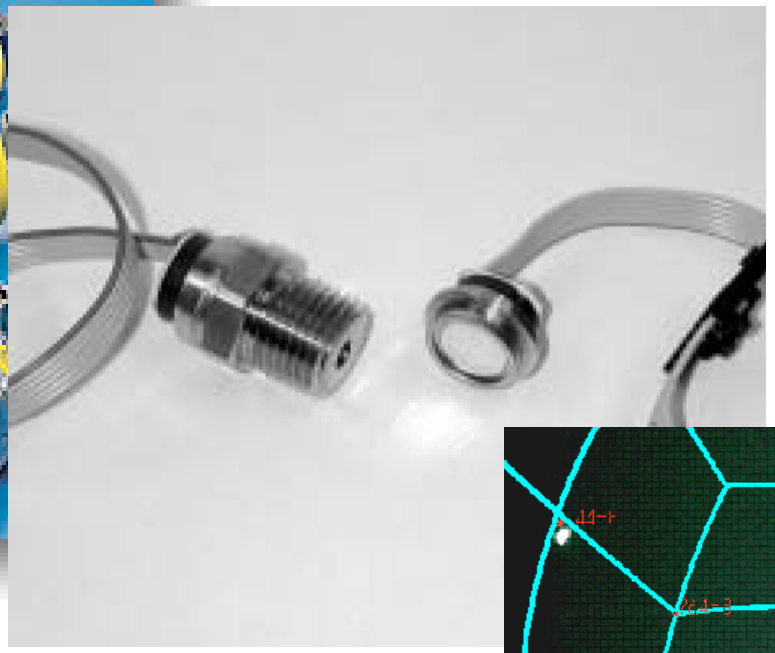
- Motor Winches and Control Cables (,)
- Number of pole segments (R)

- Counterweight for asymmetric pole deployment (R)
  - Up to 20 lbs required
  - Tungsten or stainless steel
  - Allows reach to edge of fiducial volume without long pole

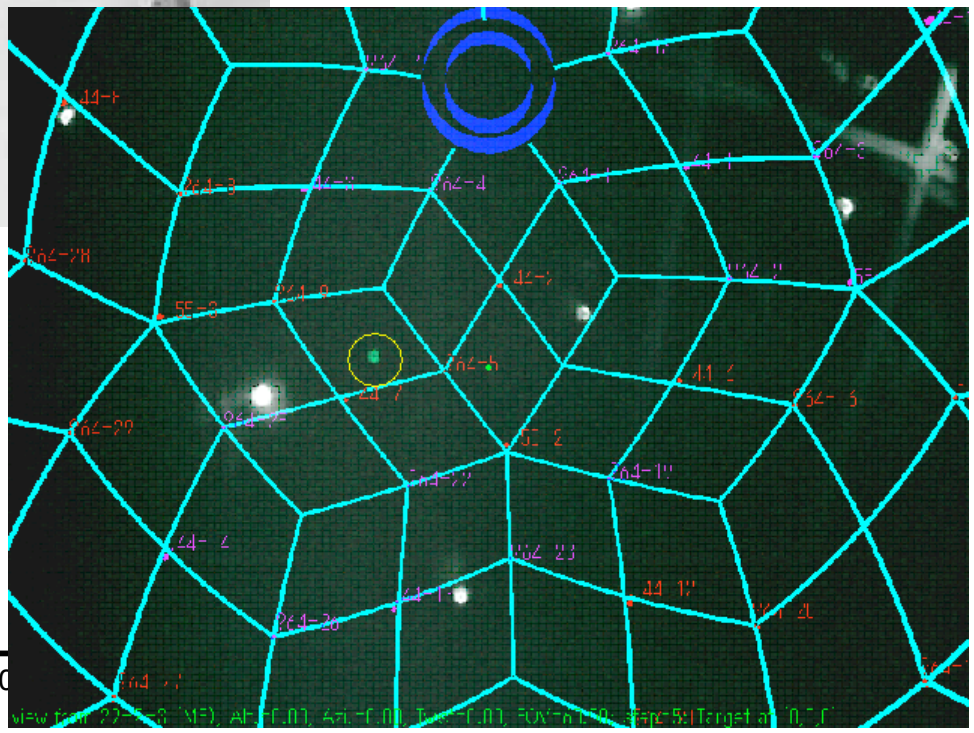
Position Monitoring and Determination



Encoders



Pressure (depth) sensors



LED imaging

Materials Compatibility

Material	Use	Approved	Required	Application
Acrylic	D, Gbox	Yes		Housing for electronics, Glovebox panels
Anodized Aluminum	Gbox	Yes		Misc Glovebox hardware
Delrin	D, Gbox		S,O	Pulleys, possibly pivot
Encased Electronics	Detector		R	Sealed circuitry for transducers, etc.
Gold	Detector	Yes	?	Pins of hermetic connectors
Kalrez	D, Gbox		S, O	Back-up for viton seals
Kevlar	Detector	Yes	S, O, R	string, webbing, cord for cabling
Mineral Oil	Detector	Yes		Lubricant for coupling threads
Nylon	D, Gbox	Yes	S, O	Material in hermetic connectors, wrench
PolyU 421 Primer	Detector		S,O	Primer for cables, polyurethane based
Polyurethane	Detector	S	O, R	cable coating
PRC 1592	Detector		S,O	Sealant for cables, polyurethane based
PTFE, teflon	Detector	S	O, R	possible cable coating, pivot hardware
PVC	Detector	?	S, O, R	possible cable coating
Silicon	Detector		S, O, R	P Transducer, made for corrosive environments
Stainless Steel 304	D, Gbox	Yes	R	weights, connectors, cords, wrench, frame
Stainless Steel 316	Detector	Yes	R	Pressure transducer housing
Titanium	Detector		S, O, R	pins, misc hardware
Titanium, 3Al 2.5V	Detector	R	S,O	tubing, couplings
Viton	D, Gbox	Yes		Seal, purchased from DuPont qualfied vendor

S - Soak Test
O - Optical Transmission Test
R - Radioassay

Radioassay of Titanium Tube and BTC Coupling

Sample weight: total 1074 g

Rnd #HC12362 = 254 g

Rnd #86075282 = 324 g

tube pieces: 496 g

counting time = ~ 49 hrs

U(early) = 19.(1) ppb

U(late) = 0.5(4) ppb

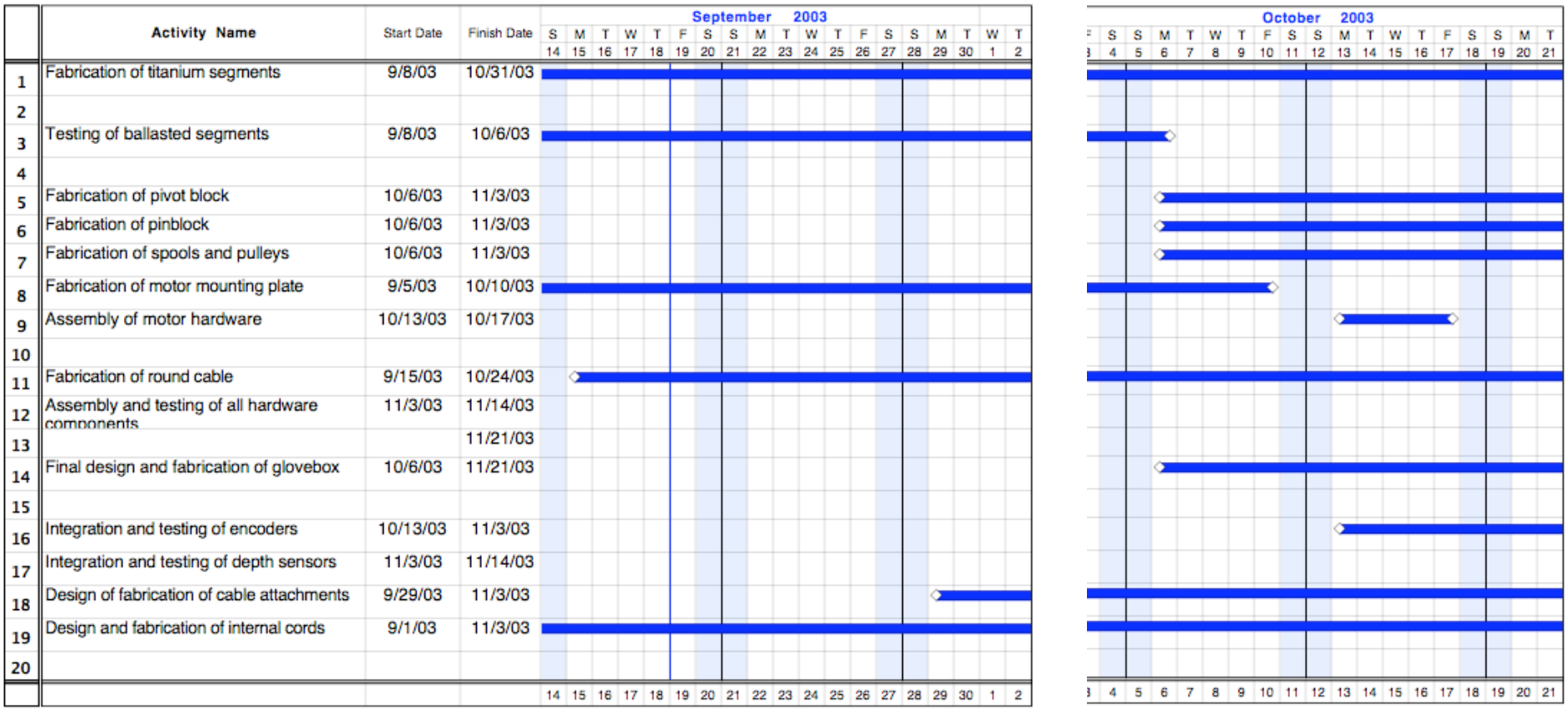
Th(early)= ND

Th(late)= 8.(1) ppb

K = 2.7(6) ppm

Schedule

	Activity Name	Start Date	Finish Date
1	Fabrication of titanium segments	9/8/03	10/31/03
2			
3	Testing of ballasted segments	9/8/03	10/6/03
4			
5	Fabrication of pivot block	10/6/03	11/3/03
6	Fabrication of pinblock	10/6/03	11/3/03
7	Fabrication of spools and pulleys	10/6/03	11/3/03
8	Fabrication of motor mounting plate	9/5/03	10/10/03
9	Assembly of motor hardware	10/13/03	10/17/03
10			
11	Fabrication of round cable	9/15/03	10/24/03
12	Assembly and testing of all hardware components	11/3/03	11/14/03
13			11/21/03
14	Final design and fabrication of glovebox	10/6/03	11/21/03
15			
16	Integration and testing of encoders	10/13/03	11/3/03
17	Integration and testing of depth sensors	11/3/03	11/14/03
18	Design of fabrication of cable attachments	9/29/03	11/3/03
19	Design and fabrication of internal cords	9/1/03	11/3/03
20			



Schedule

Completion and assembly of all hardware

	Activity Name	Start Date	Finish Date
1	Fabrication of titanium segments	9/8/03	10/31/03
2			
3	Testing of ballasted segments	9/8/03	10/6/03
4			
5	Fabrication of pivot block	10/6/03	11/3/03
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10			
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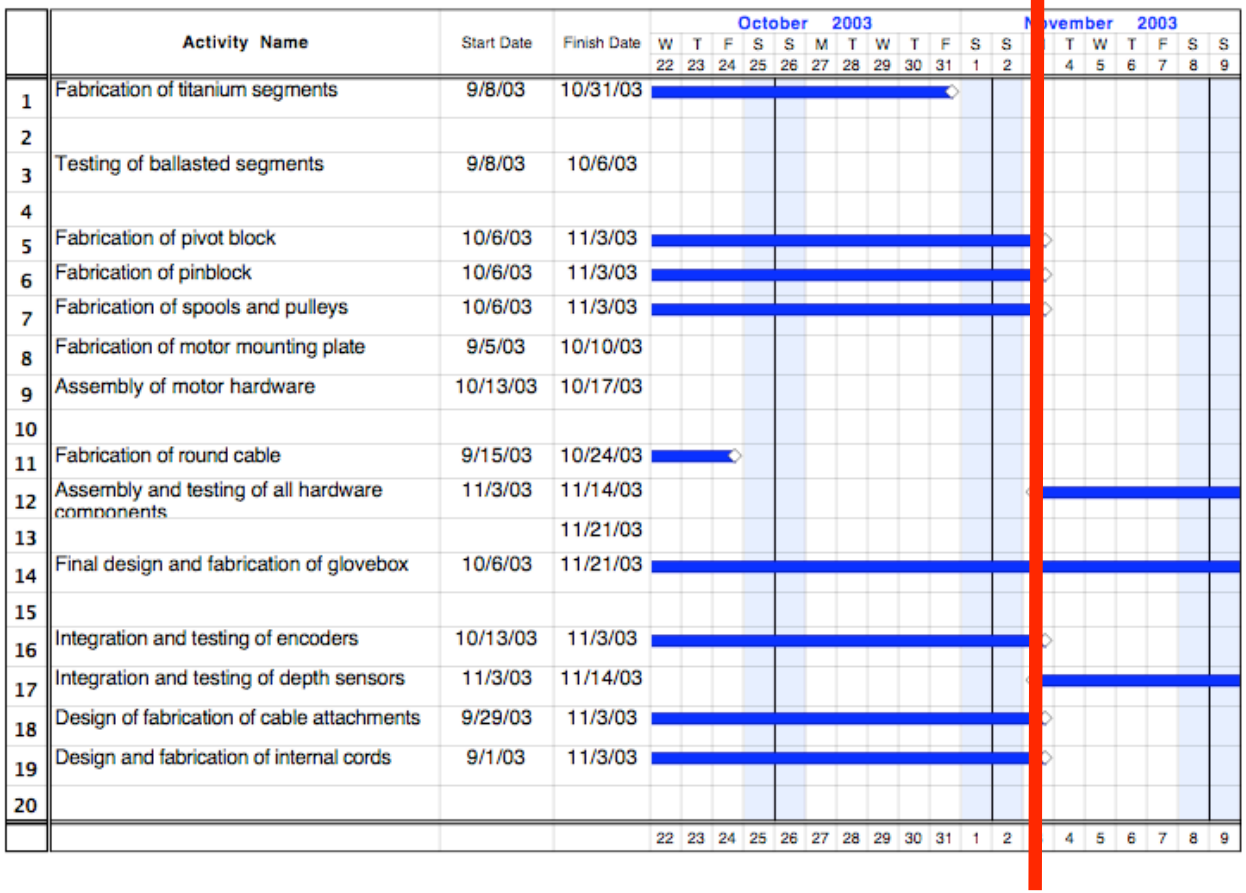
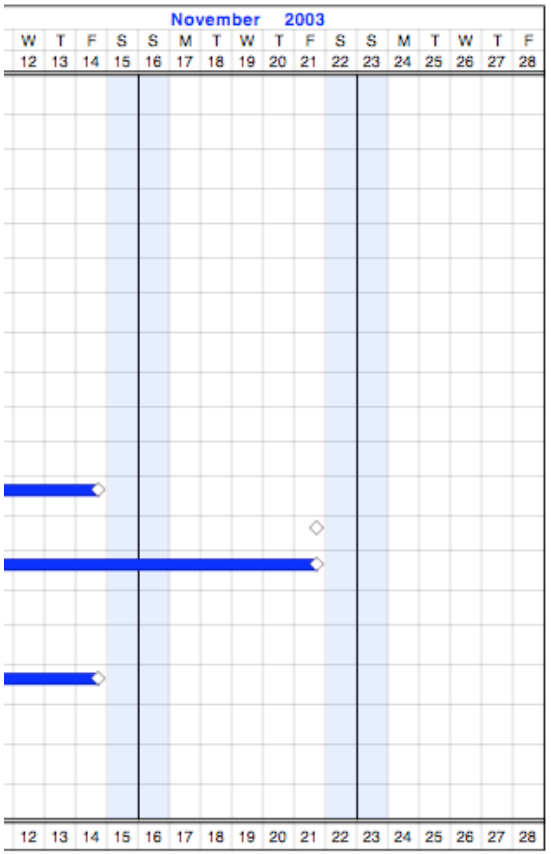




KamLAND Off-Axis Calibration System Technical Design Report

KamLAND 4π Design and Development Group

September 19, 2003

DRAFT – v0.1

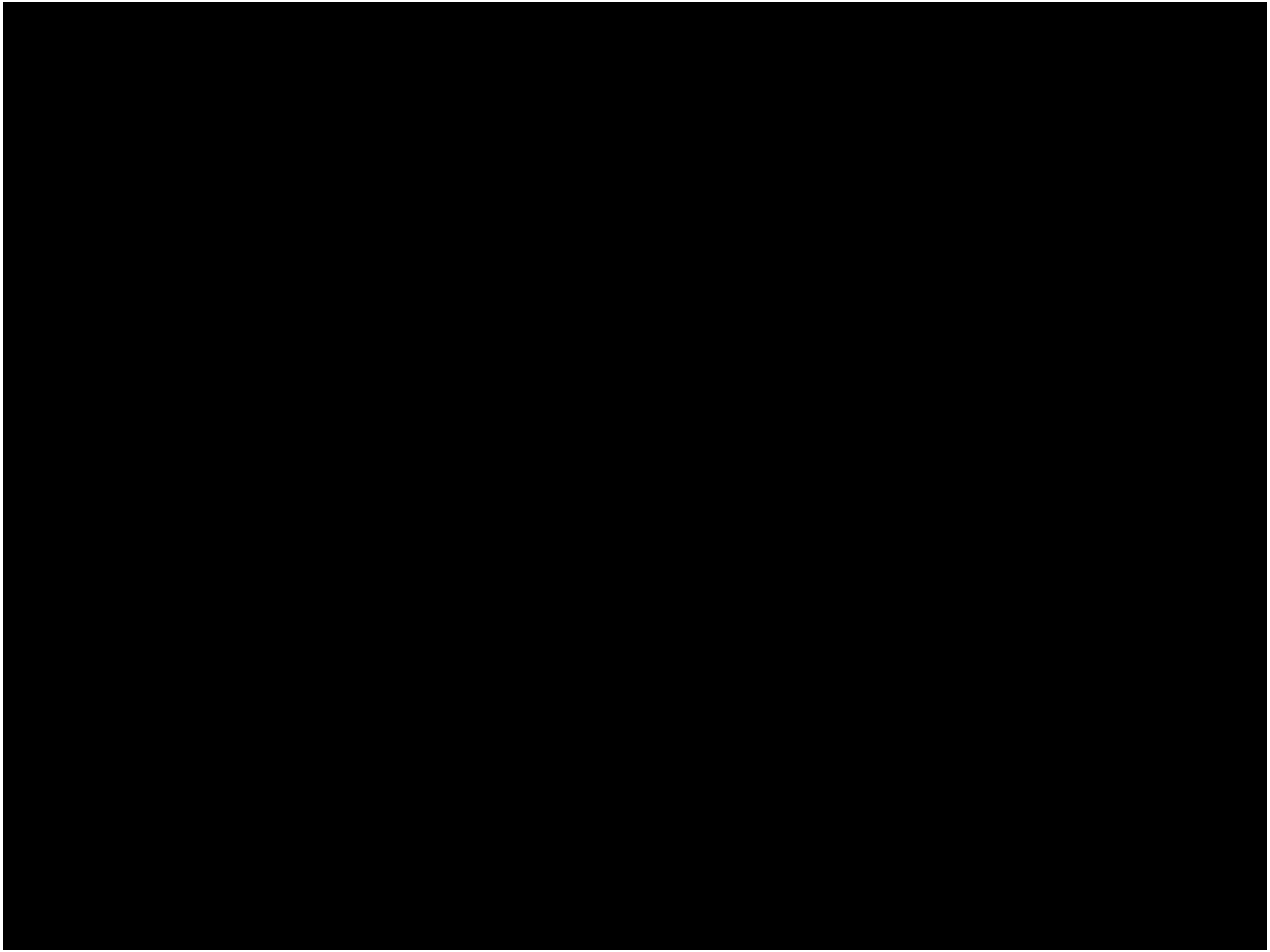
Abstract

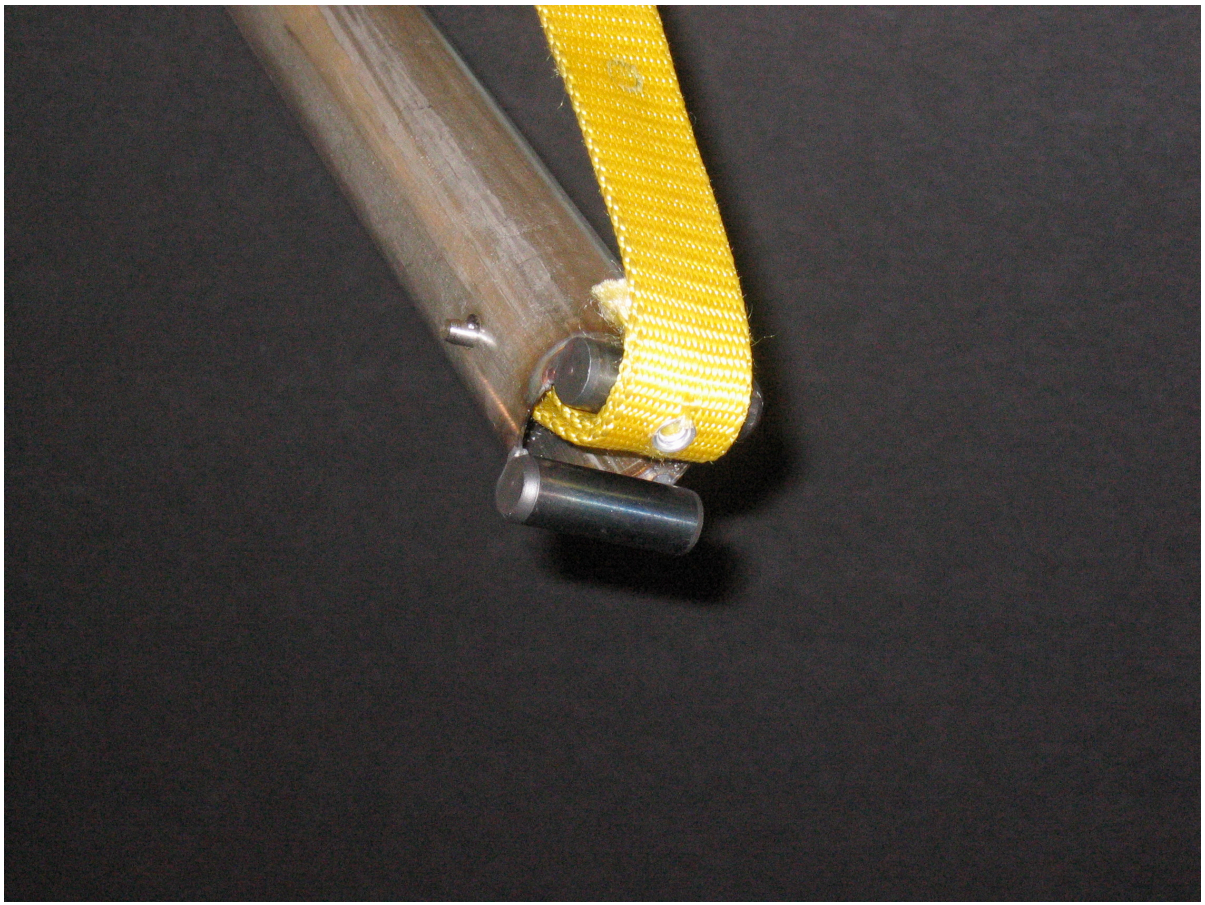
This document describes the design and specifications of a novel KamLAND off-axis calibration system, also known as the KamLAND 4π system. We give an overview of the functionality and features of this system as well as the development, prototyping, and fabrication. The safety features of this system are discussed and an installation and commissioning plan outlined. The most recent version of this document can be found at:

`http://kamland.lbl.gov/internal/4pi/design_report/`

- some 85 pages… and growing.
- still incomplete
- will provide basis for technical discussion and review

http://kamland.lbl.gov/internal/4pi/design_report/





Position Determination

- Encoders will be used to keep track of amount of each cable that is inside the detector

- Pressure transducers and LEDs will be used for accurate position determination

- LEDs will be observed with permanent CCD cameras already installed in the detector